MEMBRANE FILTRATION MANIFOLD SYSTEM

Related Applications

[0001] This application is a continuation of copending U.S. Application No. 10/045,186, filed October 18, 2001, which is a continuation, under 35 U.S.C. § 120, of PCT International Application No. PCT/AU00/00352 which has an International filing date of April 20, 2000, which designated the United States of America, which was published by the International Bureau in English on October 26, 2000, and which claims the benefit of Australian Provisional Application No. PP 9850 filed April 20, 1999.

Field of the Invention

[0002] The present invention relates to membrane filtration manifold systems. More particularly the invention relates to membrane filtration manifold systems for hollow fibre membrane filters comprising elongate bundles of hollow fibre membranes, wherein feed to be filtered is fed to the outside of the bundles of fibres and filtrate is extracted from the end or ends of the fibre lumens. The systems also preferably incorporate a cleaning facility for periodic cleansing of the feed surfaces of the fibres.

[0003] The invention has been developed primarily for use in a membrane filtration system which is open to atmospheric pressure and will be described hereinafter with reference to this application. However, it will be appreciated that the invention is not limited to this particular field of use.

Background of the Invention

[0004] Typical prior art filtration manifolds are employed in filtration systems of the type described above. These filtration systems generally include elongate tubular cartridges enclosing a bundle of the hollow fibre membranes. Manifold or header arrangements are used to connect the cartridges, usually at one or both ends, these manifolds acting to separate and divert the respective flows of the contaminated feed. filtrate and cleaning fluid through the system. In this regard, cross-flow systems typically have two feed manifolds (inlet and re-circulation outlet) and one or two filtrate manifolds. In cross-flow filtration systems of the prior art the feed stream to be filtered flows tangential to or across the surface of the membrane. This generates a sweeping action at the membrane surface,

keeping the surface cleaner. Conversely, systems configured for dead end operations utilise only one feed inlet manifold and one filtrate outlet manifold during filtration mode. Further, these prior art manifolds or header arrangements are often configured to facilitate the construction of modular two or three dimensional cartridge arrays.

[0005] Most typically, the prior art filtration systems, as previously described, are closed to the atmosphere. In such systems, fluid to be filtered, hereinafter referred to as feed, is fed under positive pressure to the filters. In order for this type of system to operate effectively, the elongate tubular filtration cartridges are encased in pressure tight housings. Such housings are then connected to a manifold system which both separates the feed from the filtrate and supports the pressure tight housing. The manifold system may also serve to introduce cleaning fluid to the filtration system.

[0006] Prior art filtration systems, as previously described, may also be open to the atmosphere. Typically in such systems, feed is drawn through the membranes under negative pressure. This is achieved by applying a negative, or suction, pressure on the filtrate side of the membrane. Such systems tend to employ less infrastructure and capital works compared with systems closed to the atmosphere as they do not require components that are able to contain relatively higher pressures. For example, there is no need to encase filtration cartridges in individual pressure tight housings in systems open to atmosphere. Typically in these systems, the filtration cartridges are merely substantially immersed in an open tank containing the feed. In such systems it is desirable that an appropriate manifold be provided to both support the filter cartridges and to allow the filtrate to be drawn from the filter while separating the feed from the filtrate. Similarly, as with closed systems, such a manifold may also serve the purpose of supporting a cleaning fluid system.

[0007] Prior art filtration systems and their associated filtration cartridges referred to above are often a complex configuration of pipes and parts which are difficult and time consuming to assemble. Further more, the actual manifold system components of the prior art filtration systems are often a complex assembly of parts in themselves.

[0008] The prior art filtration systems described above also require regular testing to assess system integrity. Non-integrity may be due to failure of individual filtration membrane hollow fibres, 'o'-rings or other system components. Integrity testing often

requires the removal of either individual system components or filtration cartridges. This removal is often difficult in typical prior art filtration manifolds. Furthermore, as previously discussed, typical prior art filtration manifolds may contain many complex parts. It then follows that integrity testing of these parts can also be time consuming.

[0009] It is an object of the present invention to provide a filtration manifold system of the kind herein described which overcomes or ameliorates at least some of the deficiencies of the prior art or at least offers a useful alternative thereto.

Summary of the Invention

[0010] According to one aspect of the invention there is provided a membrane filtration manifold for connecting a filter submodule of the kind including one or more elongate bundles of semipermeable polymeric fibres, said manifold including: a housing; and at least one submodule connecting collar connected with said housing, said collar being adapted to receive and locate said submodule having a connecting sleeve with a locking formation whereby the submodule can be secured at one end with the collar by a clip means adapted to engage both said collar and said locking formation to prevent axial withdrawal of said submodule from said collar.

[0011] Preferably, said locking formation includes a circumferential flange formed on said sleeve.

[0012] Also, in a preferred form, the housing and collars of the manifold include passageways for fluid communication between the housing and collars. Further preferably, the housing includes a removable cap for fluid-tight sealing engagement with the housing.

[0013] According to a second aspect of the invention there is provided a membrane filtration apparatus including: a filter submodule of the kind including one or more elongate bundles of semipermeable polymeric fibres; a headpiece removably connected at one end of said filter submodule; and a basepiece removably connected to the other end of said filter submodule; said headpiece being a membrane filtration manifold according to the first aspect of the invention.

[0014] According to a third aspect of the invention there is provided a membrane filtration apparatus bank including: a plurality of membrane filtration apparatuses according to the second aspect of the invention; a filtrate conduit connected to at least one membrane

filtration apparatus; and a cleaning fluid conduit connected to at least one membrane filtration apparatus.

[0015] Preferably, the module groups are arranged in an upright position, said filtrate conduit being proximally above said headpieces and said cleaning fluid conduit being proximally above said basepieces.

[0016] According to a fourth aspect of the invention there is provided a membrane filtration apparatus array including a plurality of membrane filtration apparatus banks according to the third aspect of the invention connected in parallel by an array filtrate conduit.

[0017] According to another aspect of the invention there is provided a membrane filtration apparatus array train including: a train conduit; and a plurality of membrane filtration apparatus arrays according to the fourth aspect of the invention connected in fluid communication with said train conduit.

Brief Description of the Drawings

[0018] A preferred embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings.

[0019] FIG. 1 is a perspective view of a membrane filtration manifold according to the invention.

[0020] FIG. 2 is another perspective view of the membrane filtration manifold of FIG. 1.

[0021] FIG. 3 is a sectional view showing a submodule connected to a manifold collar by a locking clip.

[0022] FIG. 4a is an isometric view of the preferred embodiment of the clip.

[0023] FIG. 4b is an isometric view of the preferred embodiment of the clip of FIG. 4a.

[0024] FIG. 4c is an isometric view of an alternate embodiment of the clip.

[0025] FIG. 5 is a cross sectional side elevation of the locking clip of FIG. 4a.

[0026] FIG. 6a is a detail view of the collar.

[0027] FIG. 6b is another detail view of the collar.

[0028] FIG. 7a is a plan view of an embodiment of the connecting sleeve for filtration modules.

[0029] FIG. 7b is a sectional view of the connecting sleeve of FIG. 8a taken on line A-A of FIG. 7a.

[0030] FIG. 7c is a side elevation of the connecting sleeve of FIG. 7a.

[0031] FIG. 8a is a plan view of an alternate embodiment of the connecting sleeve for filtration modules.

[0032] FIG. 8b is a sectional view of the connecting sleeve of FIG. 8a taken on line B-B of FIG. 8a.

[0033] FIG. 8c is a side elevation of the connecting sleeve of FIG. 8a.

[0034] FIG. 9a is a perspective view of a cap.

[0035] FIG. 9b is another perspective view of the cap of FIG. 9a.

[0036] FIG. 10 is a perspective view of the membrane filtration manifold of FIG. 1 showing the cap of FIG. 9a in use.

[0037] FIG. 11 is a side elevation of a membrane filtration apparatus bank.

[0038] FIG. 12a is a side cross sectional elevation of an embodiment of the membrane filtration manifold in basepiece configuration, showing cleaning fluid flow from the cleaning fluid conduit through the basepiece.

[0039] FIG. 12b is a front cross sectional elevation of an embodiment of the membrane filtration manifold in basepiece configuration, showing cleaning fluid flow from the cleaning fluid conduit through the basepiece.

[0040] FIG. 13 is a plan view of a membrane filtration apparatus array.

[0041] FIG. 14 is a perspective view showing one membrane filtration apparatus bank in a membrane filtration apparatus array.

[0042] FIG. 15 is an isometric view of a membrane filtration apparatus train.

Detailed Description of the Preferred Embodiment

[0043] Referring to the drawings, the membrane filtration manifold system includes a membrane filtration manifold **1** for connecting filter submodules **2** of the kind comprising elongate bundles of hollow fibre membranes. As best shown in FIGS. 1 and 2, the

preferred embodiment of the manifold includes a housing **3** connected with four submodule connecting collars **4**.

Referring to FIG. 3, the collars **4** are adapted to receive and locate submodules **2** having a connecting sleeve **5** with a locking flange **6**. In this embodiment, the submodule **2** can be secured at one end with its respective collar **4** by a clip **7** which simultaneously engages the submodule **2** and locking flange **6** to prevent axial withdrawal of the submodule **2** from the collar **4**. The locking flange **6** further engages bearingly with a lip **8** of the collar **4**. Engaging and releasing the clip **7** enables substantially simple respective assembly and removal of the submodules **2** from the manifold **1**. The manifold **1** further includes filtrate passageways **9** for fluid communication between the housing **3** and collars **4** and cleaning fluid passageways **10** for cleaning fluid communication with a cleaning fluid conduit **11**. Conduit **11** communicates with housing **3** through a number of holes or passageways **10** as shown in FIGS. 1, 2, 12a, and 12b. Once fluids enter the housing **3** they pass through passageways **9** into the collar **4**, as shown in FIG 1.

[0044] FIGS. 4a, 4b and 5 show the preferred embodiment of the clip **7**. The clip **7** has a substantially cylindrical sidewall **12** with a top and bottom flange **13** and **14**, each of which projects radially inwardly from the sidewall **12**. The clip **7** is split in a line parallel to the central axis of the submodule **2** to allow radial expansion of the clip when slid axially into and out of locking engagement with the collar **4**. Radial expansion is achieved by manually parting a pair of projections **40** provided on the top flange **13** of the clip, on either side of the split respectively. Furthermore, the clip **7** is resiliently biased to enable radial contraction of the clip when the clip snap-lockingly engages with both the submodule **2** and collar **4**. When the clip is employed to engage both the submodule and the locking flange, bottom flange **14** locks over the submodule flange **6** and top flange **13** bearingly engages with the lip **8**. Furthermore, the collar **4** has a stepped seat **15** for locking engagement with top flange **13**.

[0045] FIG. 4c shows an alternate embodiment of the clip **7**. This embodiment has additional projections **41** to aid in the manual removal of the clip **7** from both the submodule **2** and collar **4**. The additional projections **41** extend radially from the sidewall **12** of the clip **7**, on either side of the split of the sidewall **12**.

[0046] FIGS. 7a-c and 8a-c show embodiments of the submodule connection sleeves **5**. These Figures show detail of the flange **6** and 'o'-ring seat channel **17** features of the connection sleeves **5**. One side **18** of the flange **6** is for bearing engagement with the collar **4** and a second side **19** is for locking engagement with the clip **7**. Further, the embodiment of the submodule connection sleeve **5** shown in FIGS. 7a-c, has one channel **17** for use as an 'o'-ring seat, while the embodiment of the submodule connection sleeve **5** shown in FIGS. 8a-c, has two channels **17** for use as 'o'-ring seats.

[0047] The manifold **1** may also include a removable cap **20**, for fluid-tight sealing engagement with the housing. The preferred embodiment of the cap, shown in FIGS. 9a and 9b, includes a disc **21** with an axially extending threaded shaft **22** mounted to its centre on one side. The disc **21** also has projections **23** on the other side to facilitate manual turning of the cap **20**. The cap will be described in more detail below. The shaft **22** retains end cap **20** in position. There is no communication of fluid through shaft **22**.

[0048] A radially spaced flange **24** extends axially outwardly from the cap **20** on the same side of the cap as the shaft **22**. This flange allows fluid tight sealing engagement of the cap **20** with the housing **1**. FIG. 10 shows the preferred embodiment of the cap **20** in use.

[0049] In another embodiment of the invention shown in FIG. 11, a membrane filtration apparatus **25** includes a headpiece **26** and a basepiece **27**, each being an embodiment of the membrane filtration manifold **1** as described above, and connected to four membrane filter submodules **2**. Each headpiece **26** connects to a filtrate conduit **28** allowing fluid communication between each headpiece **26** and the filtrate conduit **28**. The cap **20** is not required when the membrane filtration manifold **1** is used as a headpiece **26**. Absence of the cap **20** allows fluid communication between the manifold **1** and the filtrate conduit **28**. When housing **3** is used as a headpiece, the end cap **20** is removed and filtrate withdrawn through the top of manifold **1** into filtrate conduit **28**.

[0050] Further, as seen particularly in FIGS. 12a and 12b, each basepiece **27** is connected to a cleaning fluid conduit **11** allowing fluid communication between each basepiece **27** and the cleaning fluid conduit **11**. When the membrane filtration manifold **1** is used as a basepiece **27**, the threaded shaft **22** of the cap **20** is threadedly engaged with a corresponding bore on the cleaning fluid conduit **11**. Also, in the preferred embodiment, the

clip **7** is not required to lock the submodule **2** to the basepiece. This is because the submodule **2** will be held in its respective collar **4** of its basepiece **27**, both by gravity and by virtue of the top of the submodule being held in place in its headpiece **26** and a clip **7**.

[0051] In an alternate embodiment of the invention, the shaft **22** is hollow with an internal threaded portion. In this embodiment, rather than threadedly engaging with a bore in the cleaning fluid conduit, the shaft **22** internally threadedly engages with a complementary shaft projecting in a perpendicular direction from the cleaning fluid conduit **11**.

[0052] In another embodiment of the invention, a membrane filtration apparatus bank **29** includes a plurality of membrane filtration apparatus **25** as described above wherein each headpiece **26** is connected to a filtrate conduit **28** and each basepiece **27** is connected to a cleaning fluid conduit **11**. Additional stiffening elements **30**, as shown in FIG. 11, may also be provided therebetween to aid physical stability of the filtration system. Typically, there are eight membrane filtration apparatuses **25** in each bank **29** and the apparatuses are arranged in an upright position. When employed in a filtration system, the bank **29** is substantially immersed in the feed, where the feed is contained in a tank **31** with an open top.

[0053] Preferably, air is used as the filtration submodule cleaning fluid which flows through the cleaning fluid conduit **11**. As best shown in FIGS. 11, 12a and 12b, the cleaning fluid conduit **11** is proximally above the basepieces **27** and lies in a straight line along the length of the bank **29** in between the collars **4**. This allows the cleaning fluid conduit **11** to supply air to the basepieces **27** through a plurality of passageways **10** on the under side of the cleaning fluid conduit **11**. Supplying air to the basepieces **27** through the underside of the cleaning fluid conduit **11** allows controlled release of the cleaning air, ensuring it is evenly distributed along the entire length of the bank **29**.

[0054] In another embodiment of the invention, the filtration system includes a membrane filtration apparatus array as shown in FIGS. 11 and 13 having a plurality of apparatus banks **29** wherein each of the filtrate conduits **28** are connected to an array filtrate conduit **32**.

[0055] The filtration apparatus banks **29** are further adapted for relatively simple disconnection from the membrane filtration apparatus array. When disconnected, the filtration apparatus banks may be removed from the membrane filtration apparatus array by

lifting the bank vertically from the array. Similarly, the banks may also be placed individually into an array by lowering the banks vertically into its predetermined position. This allows for less complicated assembly and disassembly of the arrays and convenient access to submodules disposed in or near the centre of the array.

[0056] In a further embodiment of the invention, a membrane filtration array train, as best shown in FIG. 15, includes a plurality of membrane filtration apparatus arrays from FIG. 14 wherein the array filtrate conduits **32** are connected by a train conduit **33** such that the array filtrate conduits **32** are in fluid communication with the train conduits **33**.

[0057] During filtration the tanks **31** are continuously substantially filled with feed which in turn submerges the arrays of filter submodules **2**. Pumps **34** draw the feed through the filter submodules **2** producing filtrate. The filtrate under negative pressure from the pumps **34**, travels through the manifolds **1**, via the filtrate conduits **28**, array filtrate conduits **32**, and train filtrate conduits **33** and on to the pump. The filtrate then leaves the pump and also the filtration system via a filtrate exit conduit **35**.

[0058] Although the invention has been described with reference to specific examples and to filtration manifolds used in filtration systems open to atmosphere, it will now be appreciated by those skilled in the art that the invention may be embodied in many other forms including filtration manifolds used in filtration systems closed to atmosphere.